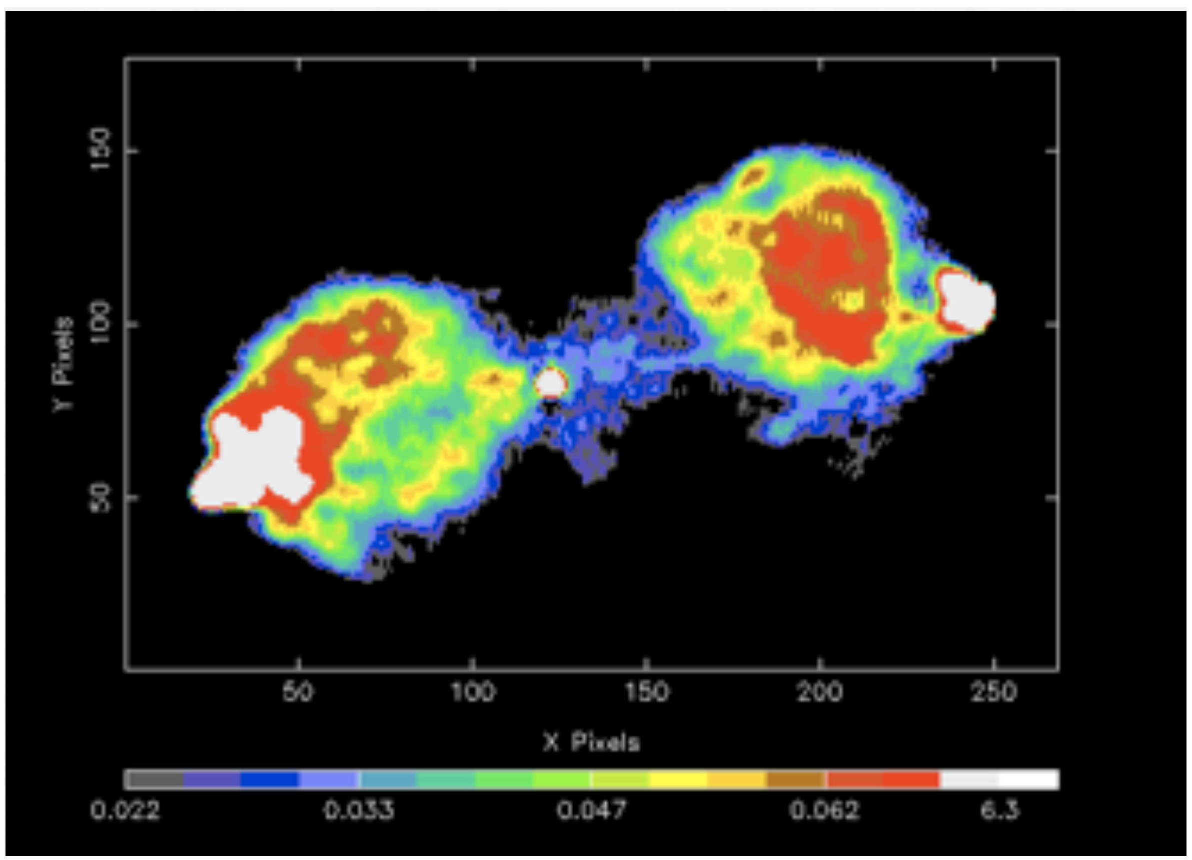
Pictor A with Chandra: jet & hotspot

Pic A is a nearby (z =0.035) radio galaxy optically classified as broad-line radio galaxy.

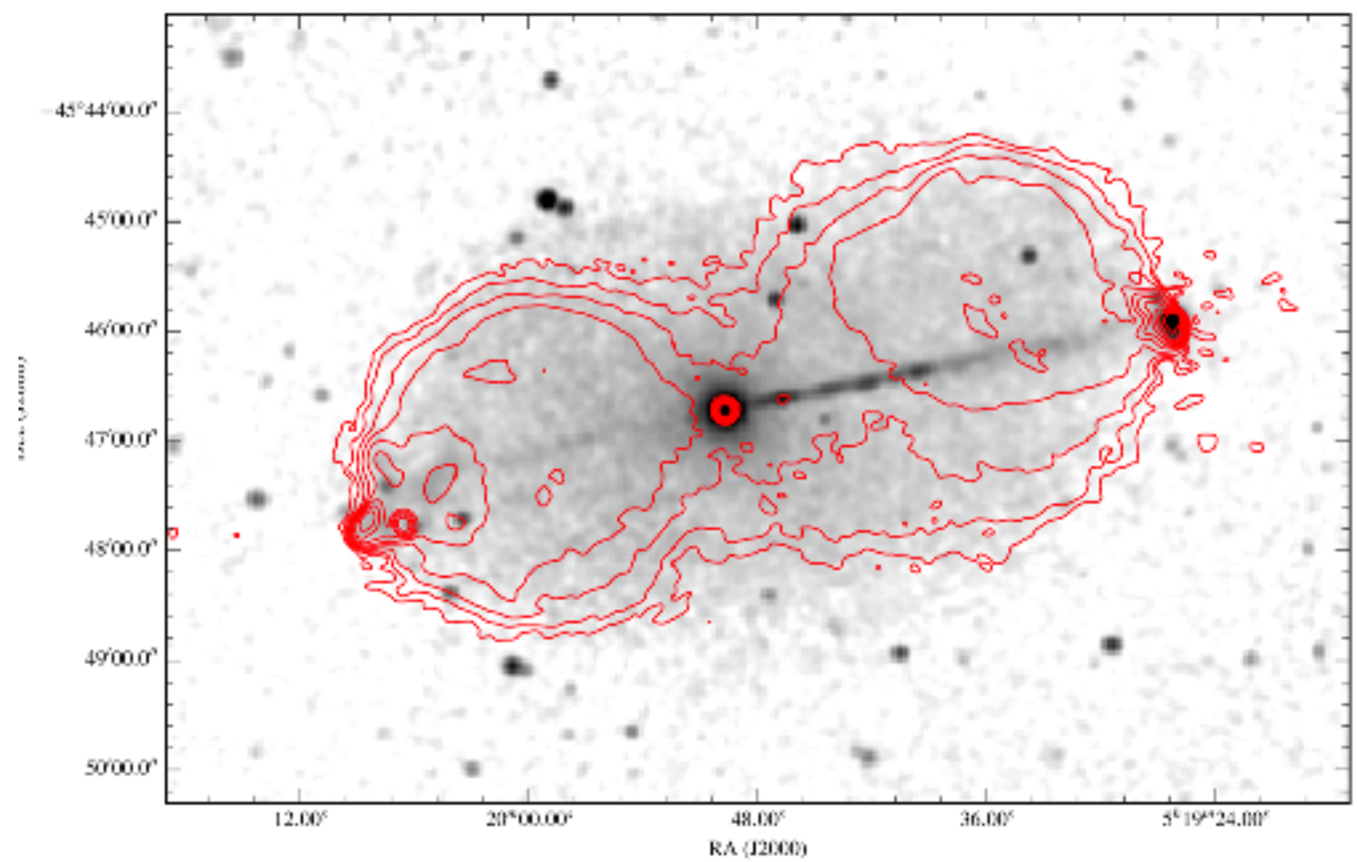
It is an isolated source.

It is a double-lobed radio source with a FR II morphology

VLA 20 cm



Chandra 0.5-5keV + radio contours (5.5 GHz)

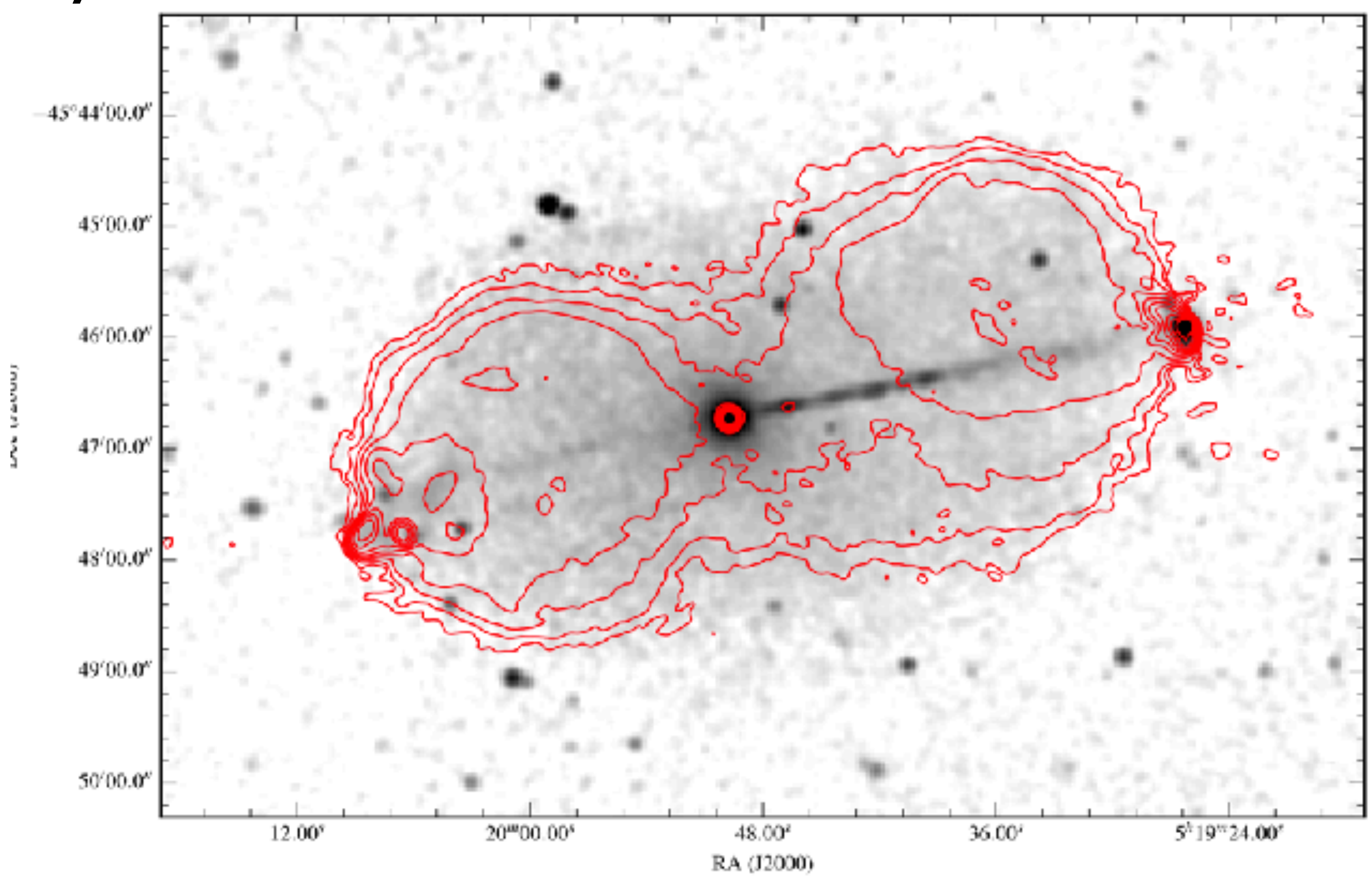


Analysis of the Chandra Observation: jet and western hot spot

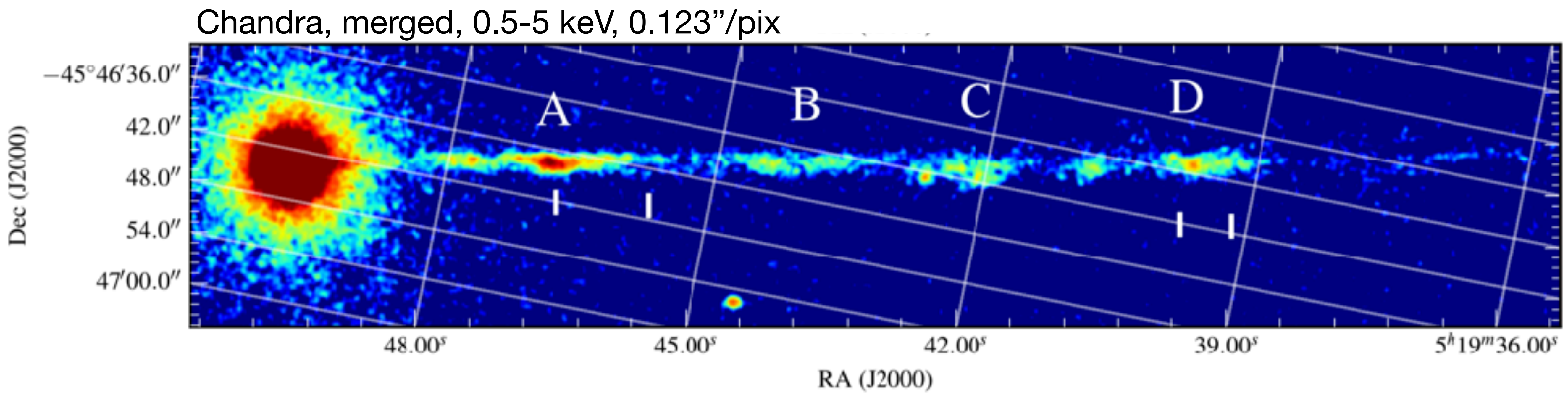
Merged Observation: morphological study

Datasets: merged file of 15 Chandra observations from 1999 to 2015, 466 ks exposure time.

Superposition of the X-ray and radio images (DS9) to identify the regions for the X-ray analysis.

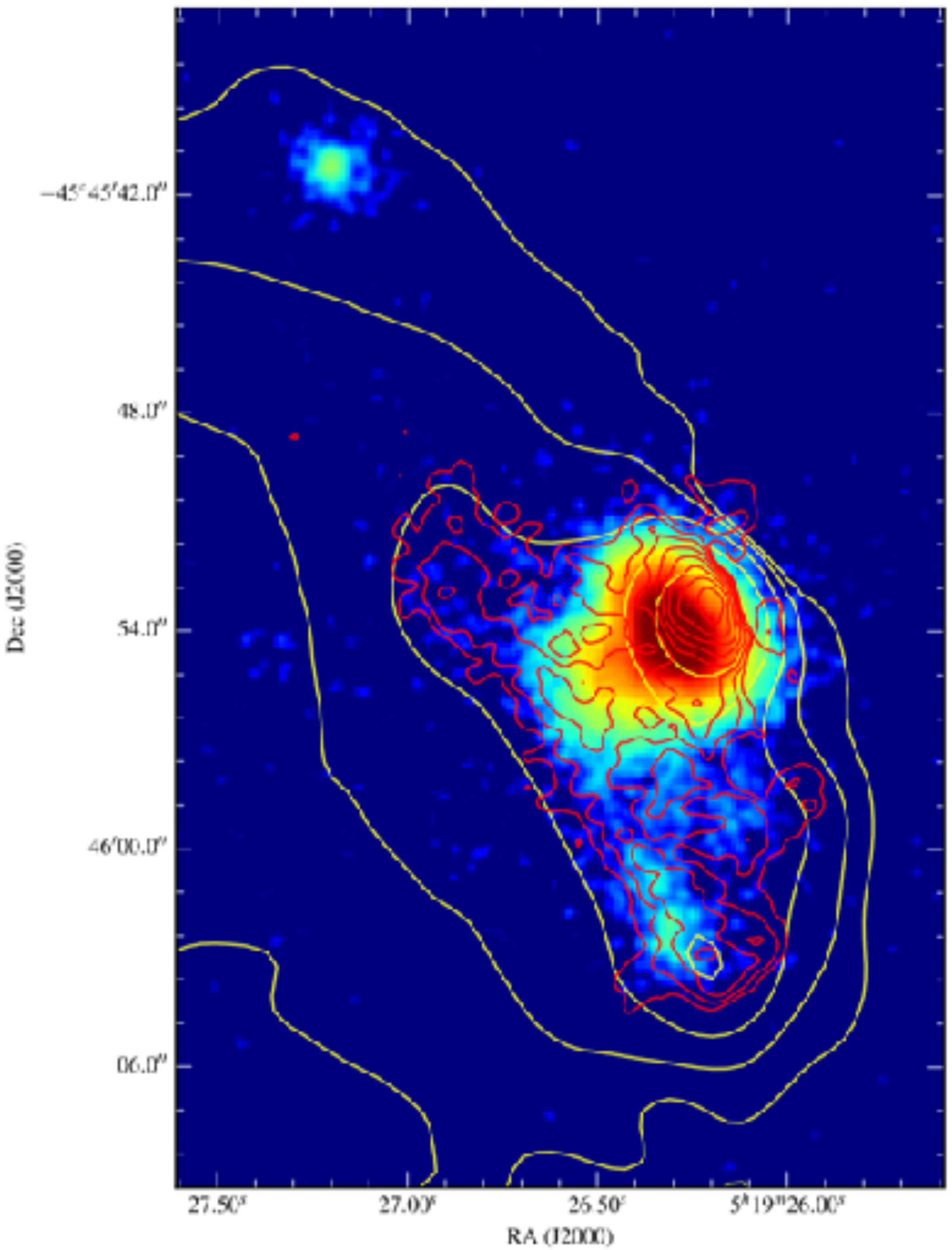


X-ray study of the jet knot



- Jet: extraction of the spectrum of the knot B (supposed to be variable) and production of the .rmf and .arf files (CIAO) from T>40 ks obs (1 spectrum per each observation);
- Spectral analysis with XSPEC. Definition of the best data model: parameter uncertainties, confidence (68%, 90%, 99%) contour plots, flux and luminosity (variability?);
- Optional 1: spectral analysis of the co-added X-ray spectra of knot B (same procedure as 4C 29.30);
- Optional 2: brightness profiles of the X-ray jet (with ds9).

Western hot spot: X-ray study & SED



Chandra, merged, 0.5-5 keV, 0.123”/pix
+
radio contours (5.5 GHz+15 GHz)

- extraction of the spectrum/spectra and production of the .rmf and .arf files (CIAO) of the Western hotspot from T>40ks observations (1 spectrum per each observation);
- Spectral analysis with XSPEC. Definition of the best data model: parameter uncertainties, confidence (68%, 90%, 99%) contour plots, flux and luminosity;
- 2002-1014 temporal behaviour of the hotspot: chi^2 applied to the long-term light curve of the hotspot.

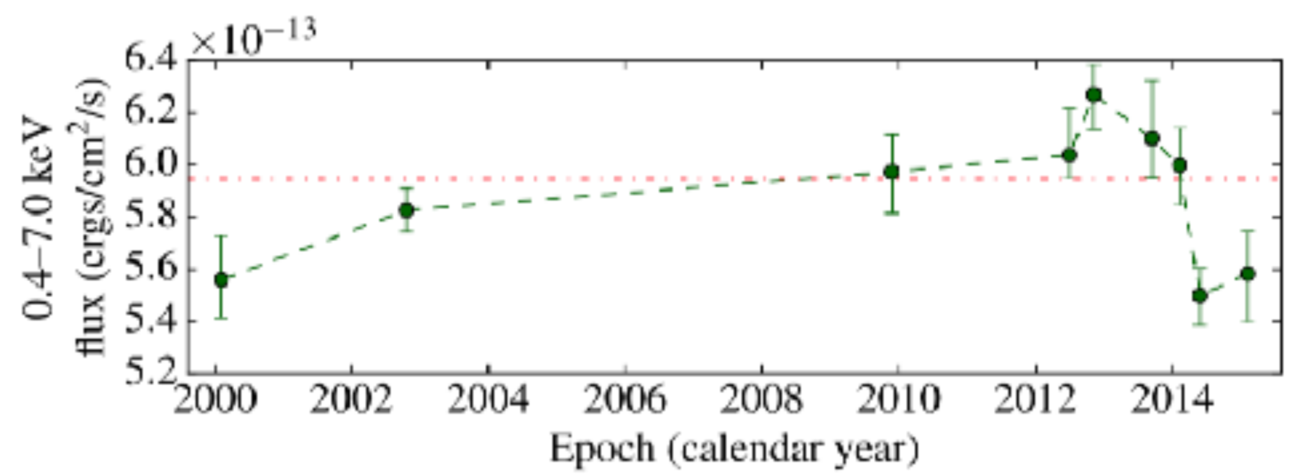
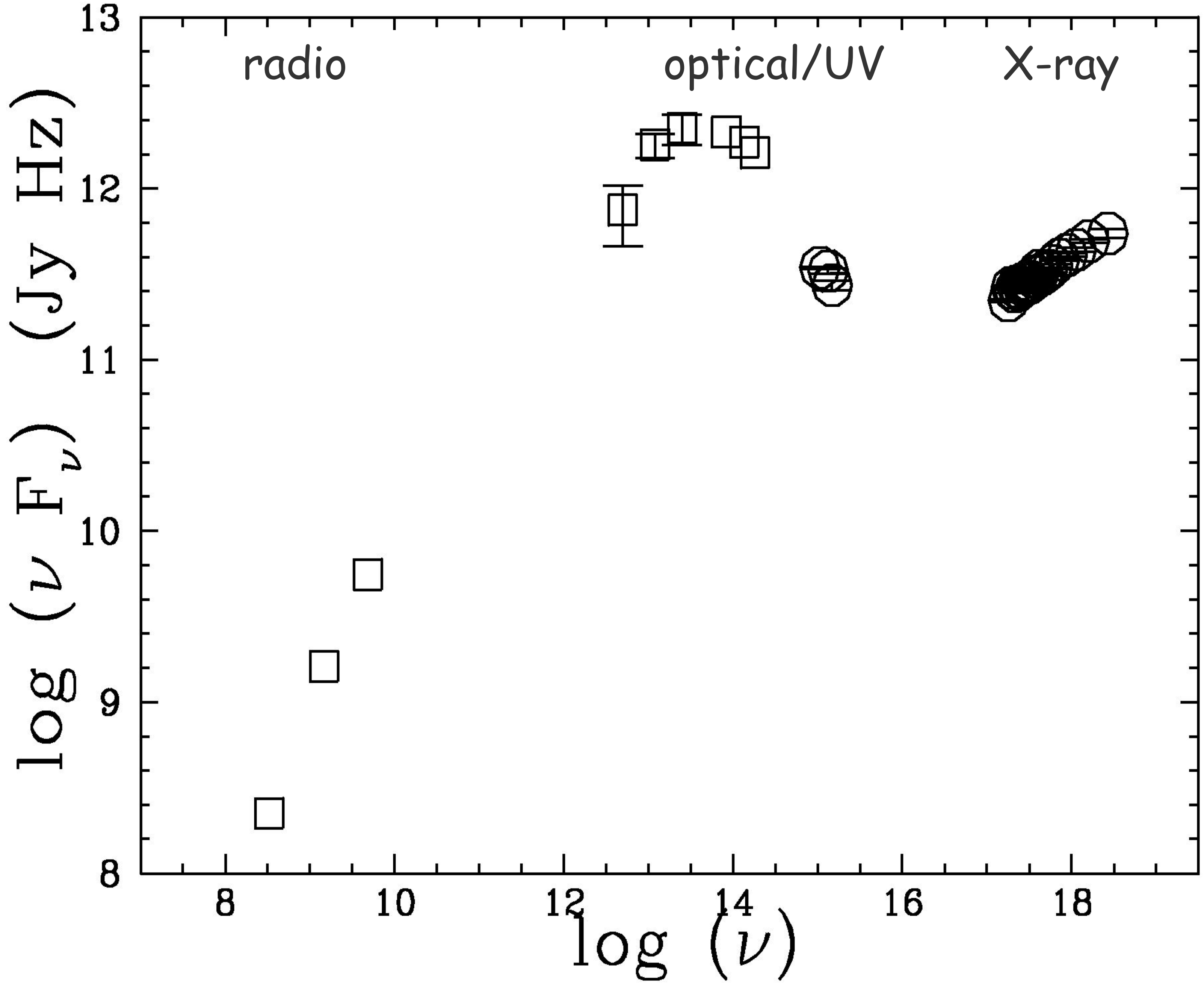


Figure 8. The best-fitting photon indices, 1 keV flux densities and total flux in the *Chandra* band for a single power-law model of the W hotspot as a function of observing date. Red dashed lines show the values derived from a joint fit to the data, effectively a weighted mean for all the observations.

see http://adsabs.harvard.edu/abs/2016MNRAS.455.3526H

Western hot spot - SED

- Optional 1: spectral analysis of the co-added X-ray spectra of Western hotspot (1 spectrum per observation);
- Optional 2: plot of the hot spot SED (see next slides).



Western hot spot - SED

Radio Data

SED HOT SPOT PICTOR A

λ (cm)	Flux (Jy)
2	1.6
3.6	1.5
6	2.1
20	5.3
90	16

HST Data

$\lambda(\AA)$	$Flux(\mu Jy)$
2900	30
6130	104

Western hot spot - SED

Infrared

Meisenheimer et al. 1989 A&A 219,63

Table 2. Hot spot photometry at optical, near-infrared and millimetre wavelengths

Hot spot	λ [μm]	ν [Hz]	S_ν(obs) [μJy]	S_ν(corr)[a] [μJy]	Remarks
Pic A west	0.45	$6.67\,10^{14}$	68 ± 7		from Paper III
	0.67	$4.48\,10^{14}$	130 ± 15		$A_V = 0.00 \pm 0.03$
	1.25	$2.40\,10^{14}$	126 ± 25		
	1.63	$1.84\,10^{14}$	165 ± 43		
	2.20	$1.36\,10^{14}$	223 ± 35		

[a] Corrected for galactic extinction: The extinction E_{B-V} is taken from the maps of Burstein & Heiles (1982). We assume the standard extinction law given by Savage & Mathis (1979) with $A_V = 3.1E_{B-V}$.
[b] The value at $b_{\mathrm{II}} = -10°$ is extrapolated to $b_{\mathrm{II}} = -8.8°$ by using the HI column from Weaver & Williams (1973).

Table 1
WISE Properties of the West Hot Spot of Pictor A

Band	λ (μm)[a]	SN[b]	m (mag)[c]	F_ν (mJy)[d]	σ_{sys} (mJy)[e]	f_c[f]	f_r[g]
W1	3.35	45.8	13.368 ± 0.024	1.39 ± 0.03	0.03	0.992	1
W2	4.60	50.2	12.324 ± 0.022	2.02 ± 0.04	0.06	0.994	1
W3	11.56	35.7	9.569 ± 0.03	4.60 ± 0.13	0.21	0.937	1
W4	22.09	13.1	7.215 ± 0.083	9.98 ± 0.76	0.57	0.993	0.92

Notes.
[a] The isophotal wavelength of the *WISE* photometric band.
[b] The signal-to-noise ratio.
[c] The source magnitude in the Vega unit.
[d] The corresponding flux density.
[e] The systematic error of the *WISE* photometry (Jarrett et al. 2011).
[f] The color-correction factor for $\alpha = 1$.
[g] The additional correction factor for red sources (see Wright et al. 2010).

Isobe et al 2017
The Astrophysical Journal, 850:193 (7pp), 2017

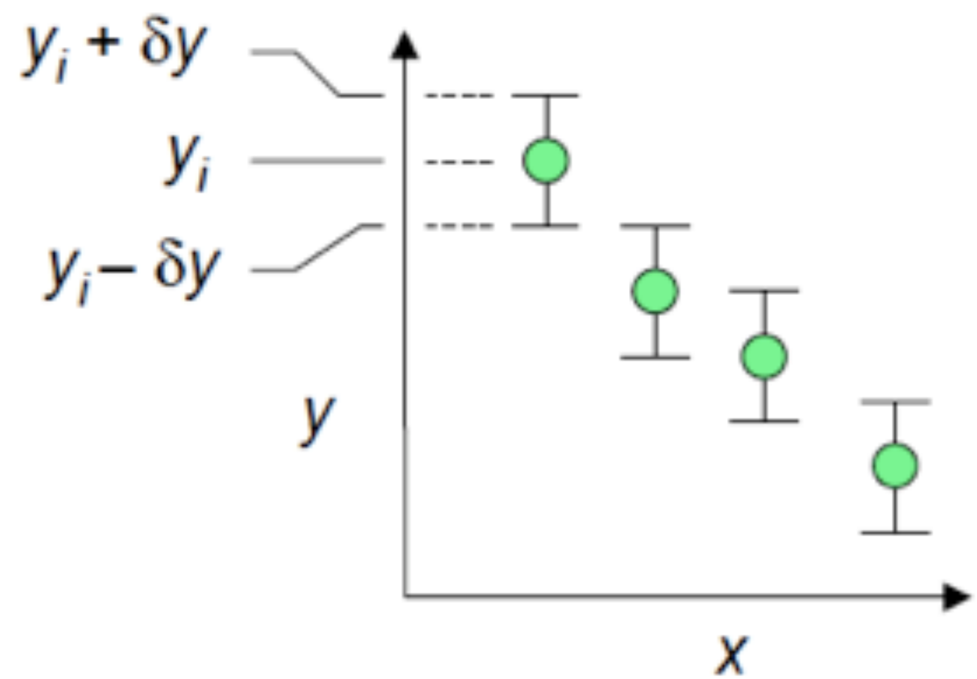
References

- Wilson et al. 2001, ApJ 547, 740
- Marshall et al. 2010, ApJL 714, 213
- Hardcastle et al. 2016, MNRAS 455, 3526
- Perley et al. 1997, A&A 329, 12

Logarithmic Error Bars

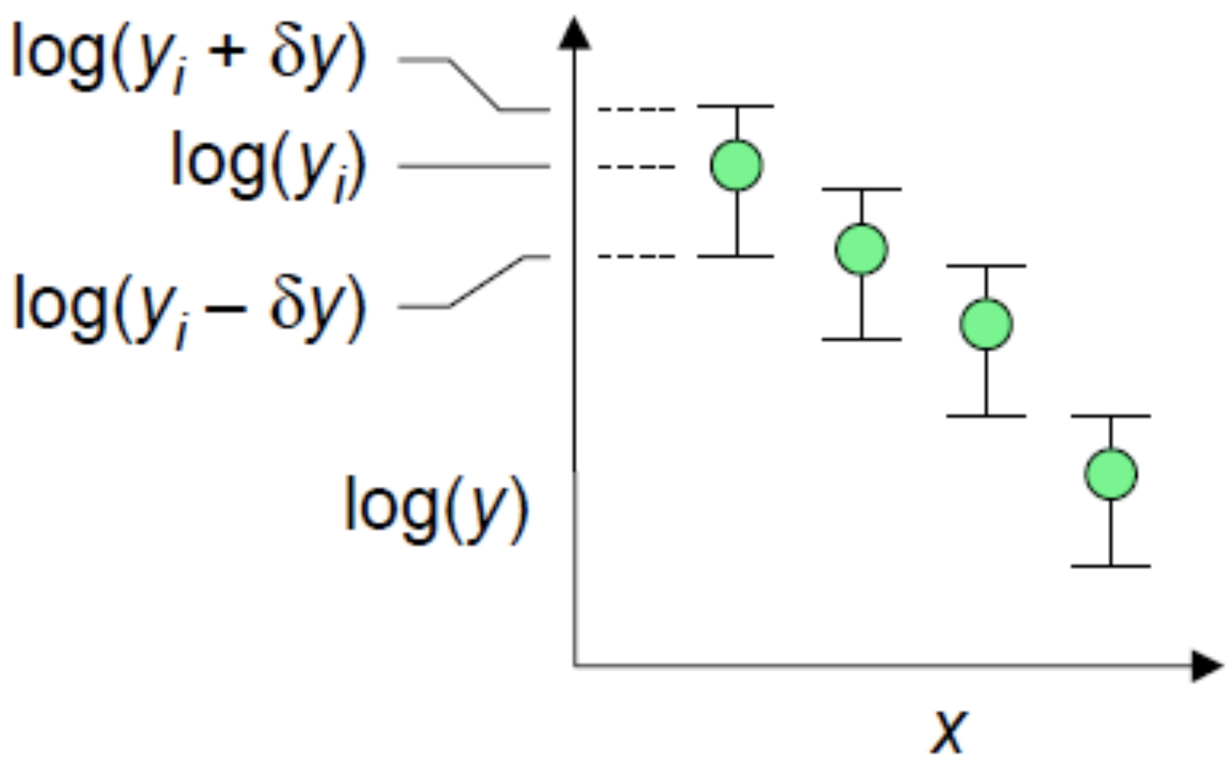
- Suppose that one has a sufficient number of measurements to make an estimate of a measured quantity y and report its error, $\pm \delta y$.

- The error, $\pm \delta y$, is represented on a Cartesian plot by extending lines of the appropriate size above and below the point y.



log Error Bars (cont.)

- If plotted on a logarithmic plot, however, this practice leads to asymmetric error bars.



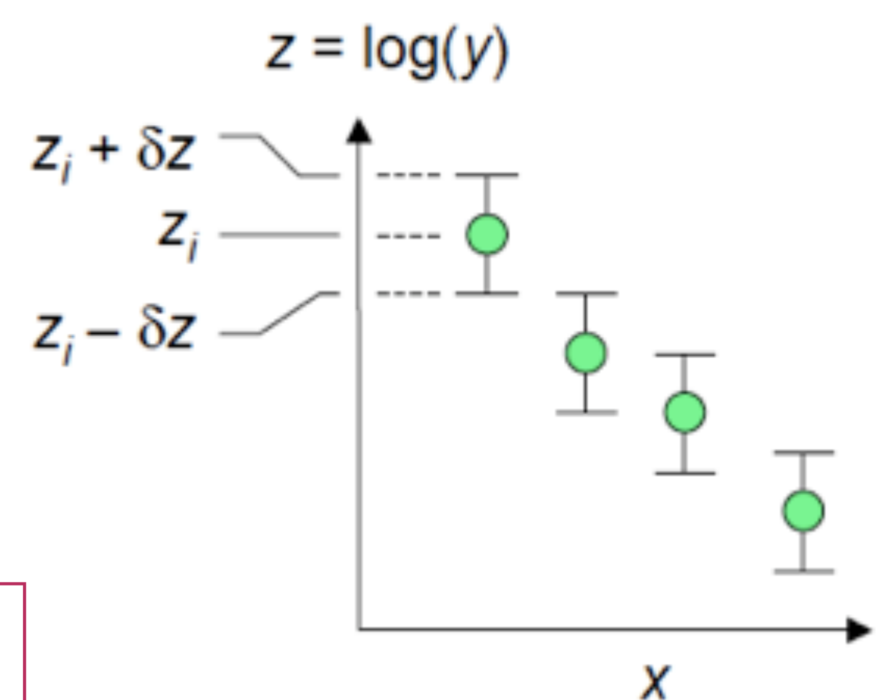
log Error Bars (cont.)

- On the assumption of small errors, a differential analysis can be used

$$\delta z \approx dz = d\left[\log(y)\right] = \frac{1}{2.303}\frac{dy}{y} \approx 0.434\frac{\delta y}{y}$$

- The error δz is thus given by the *relative error* in y

$$\delta z \approx 0.434\frac{\delta y}{y}$$



ln(10)